Precambrian Geology of Northeastern Alberta

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Summary

This poster presents the new digital compilation map at scale 1:250,000 of two distinct Precambrian lithotectonic assemblages in northeastern Alberta: a) Archean to Paleoproterozoic metamorphic and igneous rocks of the Alberta shield and b) late Paleoproterozoic clastic strata of the western Athabasca Group. Both entities have been and continue to be of interest for the mineral exploration industry (particularly for uranium), academia and government organizations.

Data Sources

For the Alberta shield, the compilation is based on detailed mapping by the Alberta Geological Survey at scale 1: 31,680 between 1958 and 1987. Between 1994 and 2000, the Geological Survey of Canada selectively remapped portions of the Alberta shield at scale 1:50,000, conducted geochrono-logical studies and published the results as preliminary 'Open file', 'A Series' maps and journal articles. The compilation also includes a series of updates derived from the author's own field work and analytical (geochemical and isotope) data collected and published between 2004 and 2009. An effort has been made to integrate all published isotope data in the compilation: locations of U-Pb and $^{40}Ar/^{39}Ar$ samples are marked on the map and the age data summarized in accompanying tables. Sm-Nd T_{DM} model ages and epsilon Nd values are given in the legend as ranges of variations for all map units that benefited from such analyses. The author of the compilation has attempted to present the geological information on the Alberta shield in a neutral manner, unbiased by the three, mutually exclusive regional tectonic concepts existing at the time of the compilation.

For the Athabasca Basin the compilation is based on stratigraphic studies sponsored and published by the Alberta Geological Survey and the Geological Survey of Canada between 2000 and 2007.

Map Units and Geochronological Data for the Alberta Shield

The Alberta shield encompasses a portion of the Taltson magmatic zone (TMZ), which makes up the southern segment of the approximately 3000 km long, north-trending, Early Proterozoic (2.0–1.9 Ga) Thelon-Taltson orogenic belt. The TMZ forms a ca. 600 km by 100 km belt extending from the Great Slave Lake shear zone in the Northwest Territories to the Snowbird tectonic zone in central Alberta (e.g., Hoffman, 1988). It has been interpreted as a subduction/collision Andean-type orogen (e.g., McDonough et al., 2000); as a Tian Shan–type orogen developed in a plate-interior setting, in response to distant plate boundary compression (Chacko et al., 2000; De et al., 2000); and as an intracontinental orogen triggered by mantle downwelling and Rayleigh-Taylor–type flow-induced stress at the base of a crust weakened by high radioactive-heat production (Pană et al., 2007).

In Alberta, the main area of the exposed Taltson magmatic zone consists of ca. 1.97–1.93 Ga granitoid rocks that intruded and reworked Archean to Paleoproterozoic Rae crust at the northwestern margin of the Churchill Province (e.g., Chacko et al., 2000; McDonough et al., 2000; McNicoll et al., 2000). The westernmost relic of the Rae crust is the Taltson basement complex, represented by a curving, generally northerly trending succession of Archean (3.2 Ga, 3.1 Ga, 2.6 Ga) and Early Proterozoic (2.4–2.1 Ga) metaplutonic gneiss units. Enclosed bands of migmatized supracrustal gneiss and minor amphibolite have been inferred to be derived from ca. 2.13–2.09 Ga clastic sedimentary rocks of the Rutledge River Basin and the amphibolite from metamorphosed ophiolite remnants (Bostock and van Breemen, 1994; McNicoll et al., 2000). Bands of low-grade metamorphic sequences are assigned to the Waugh Lake Complex southeast of Andrew Lake and to the Burntwood Complex on the north shore of Lake Athabasca.

The Taltson basement complex is flanked by moderately to strongly foliated granitoid plutons with minor Taltson basement complex roof pendants. Plutons on the east side consist of older, weakly peraluminous to metaluminous I-type granitoid rocks: 1) the ca. 1971 Ma Colin Lake granodiorite to quartz diorite; 2) the ca. 1974–1963 Ma Wylie Lake–Fishing Creek suite of granodiorite, quartz diorite and quartz monzonite; and 3) the ca. 1962–1959 Ma Andrew Lake suite of granodiorite to diorite. Plutons on the west side of the Taltson basement complex are younger, have peraluminous S-type granitoid compositions, are characterized by abundant mafic clots of biotite, garnet, andalusite, hercynite and cordierite, and include 1) the ca. 1960–1934 Ma, polyphase Slave granite to monzogranite; and 2) the ca. 1938 Ma Arch Lake quartz monzogranite to syenogranite. Several smaller, variously foliated plutons of uncertain geochemical affiliation are enclosed in the Taltson basement complex: 1) the Charles Lake granite suite with monazite metamorphic ages of ca. 1933–1919 Ma; and 2) the ca. 1925 Ma Chipewyan and Thesis syenogranite to quartz monzonite suite (Chacko et al., 2000; De et al., 2000; McDonough et al., 2000). During the emplacement of the late plutons, peak metamorphic conditions reached pressures of 6–7 kbar and temperatures as high as 1045°C (Berman and Bostock, 1997). From west to east, the following major, northerly trending, high- to low-grade shear zones cross the Alberta–Northwest Territories border: the Leland Lakes, Charles Lake and Bayonet Lake shear zones. The crosscutting relationships between shear zones and granitoid bodies are very complex, indicating concurrent deformation and granitoid intrusion during the ca. 2.0–1.9 Ga Taltson tectonothermal event. Shear zone deformation between ca. 1.95 Ga and 1.93 Ga was initiated at pressures of approximately 5–7 kbar and temperatures of 800°–850°C (Grover et al., 1997).

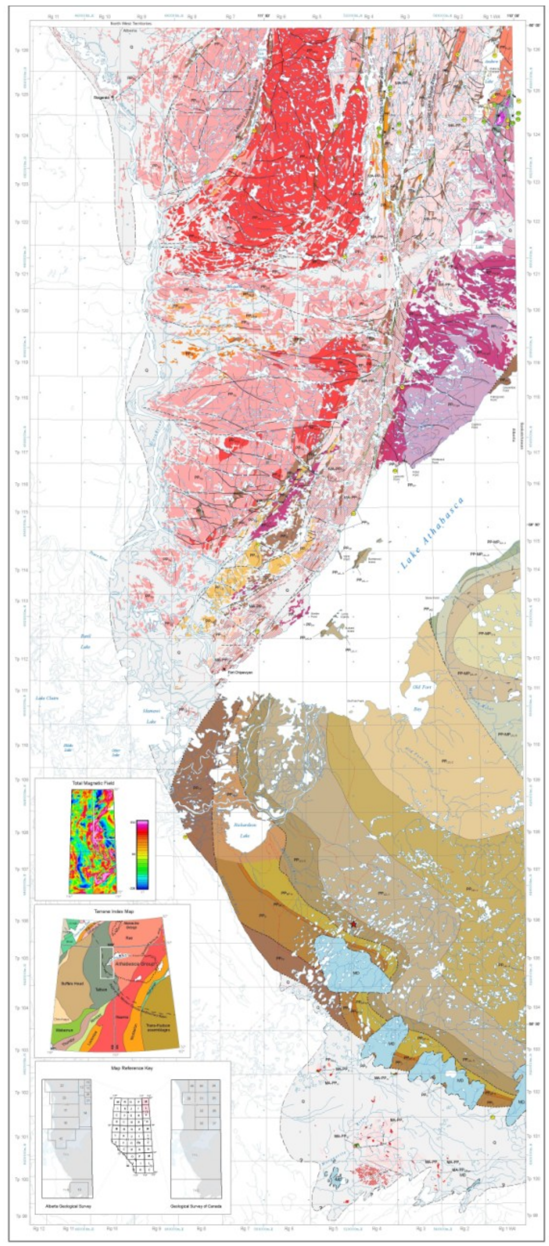

Figure 1:
Precambrian Geology of Northeastern Alberta

Map Units of the Athabasca Group

The late Paleoproterozoic to early Mesoproterozoic Athabasca Group straddles the Alberta-Saskatchewan border, with approximately 10% of its area in Alberta, where it lies on the TMZ and possibly its Rae infrastructure at the western margin of the Churchill Province. The Athabasca Group comprises four unconformity-bounded quartzose fluvial sequences, which show distinct sub-basin architecture, grain-size distribution, and paleocurrent directions (e.g., Ramaekers et al., 2007). Discontinuities in paleocurrent-direction patterns and maximum-grain-size distribution separated by unconformities show that Athabasca Group sediments were deposited as four distinct sequences in three distinct, stacked sub-basins.

Sequence 1 is confined to the Jackfish sub-basin in the western part of the Athabasca Basin and consists of the Fair Point Formation. It is of nearby derivation and underwent considerable compaction under inferred greater stratigraphic thickness before being extensively eroded to a thickness of ca. 380 m. A prominent unconformity, suggesting a considerable hiatus, separates sequences 1 and 2. ***Sequence 2*** is confined to the Cree sub-basin, which reaches its greatest depth in the eastern part of the Athabasca Basin, but overlies sequence 1 almost completely, except for a narrow belt along the western Athabasca Basin margin. Sequence 2 begins with the well-sorted, sandy Smart Formation in the west and Read Formation in the east, which are overlain by the Manitou Falls Formation that spans the entire Cree sub-basin. In Alberta, it consists of distal relatively fine-grained and thin units derived predominantly from the east. The upper part was probably eroded and the preserved aggregate thickness is up to 1100 m. Abrupt paleocurrent-direction discontinuities indicate a major basin reorganization between sequence 2 and the overlying sequences 3 and 4. ***Sequences 3 and 4*** are found in the Mirror sub-basin, overlying the Cree sub-basin in the central area of the Athabasca Basin, and their sediments are derived largely from the south. Sequences 3 and 4 have similar paleocurrent patterns, suggesting a lesser degree of discontinuity between them. Sequence 3, with an aggregate maximum preserved thickness of about 600 m, includes the Lazenby Lake and Wolverine Point formations, widespread in the central and western parts of the Athabasca Basin. Sequence 4 comprises the Locker Lake and Otherside formations, which are limited to the central portion of the Athabasca Basin, and the Douglas and Carswell formations, which are restricted to the Carswell meteorite structure, Saskatchewan.

The preserved aggregate thickness is estimated at 1150 m. Although erosion in different places at different times and lateral thickness variation of individual lithostratigraphic units prevent direct estimates of the entire thickness of the Athabasca Group, it is inferred that the aggregate thickness of stratotypes amounts to 3800 m (Ramaekers et al., 2007). The timing of Athabasca Group deposition is poorly constrained by the cessation of the tectonothermal evolution of the basement at ca. 1800 Ma and by ca. 1300 Ma crosscutting mafic dikes. Additional time constraints are provided by the U-Pb zircon age of 1644 ±13 Ma, from tuffaceous intraclasts of the Wolverine Point Formation (Rainbird et al., 2007), and the Re-Os isochron age of 1541 ±13 Ma, yielded by organic matter from black mudstone of the Douglas Formation (Creaser and Stasiuk, 2007). Based on these data and stratigraphic relationships, the Athabasca Group is inferred to have been deposited between ca. 1760 Ma and 1500 Ma.

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